

IMAGING BY MAGNETIC RESONANCE ADSORPTION, ELASTOGRAPHY
AND TOMOGRAPHY

RELATED APPLICATIONS

[0001] This application claims benefit of priority to and is a continuation-
5 in-part of provisional application serial no. 60/414,617 filed September 27, 2002.

FIELD OF THE INVENTION

[0002] This invention relates to magnetic resonance (MR) imaging
systems and microwave tomography systems. In particular, a system combines MR
microwave absorption imaging with MR-compatible microwave tomography to
10 differentiate biological tissues having different electrical properties. These techniques
may also be combined with data generation in magnetic resonance elastography
(MRE).

BACKGROUND

[0003] MR elastography (MRE) involves measuring motion resulting from
15 low frequency vibration. Present MR elastography methods use a separate gradient
waveform to encode the motion, for example, in context of the Larmor equation that
is used to measure tissue strain and discussed in United States Patent No. 5,982,828
issued to Rossman et al. The gradient waveform may be added between the RF
excitation and the readout of the echo. The resulting increased echo time has the
20 undesirable effect of decreasing the signal amplitude, as well as increasing the
imaging time.

[0004] MRE has shown promise in tissue imaging, including breast
imaging. Several acquisition methods with corresponding reconstruction methods
have been used to find the shear modulus of tissue in vivo. The first elastographic
25 methods used ultrasound to measure static and dynamic displacements and the raw
strain images were interpreted without reconstruction. See J. Ophir et al.,
"Elastography: A Quantitative Method for Imaging the Elasticity of Biological
Tissues," Ultrasonic Imaging, 13:111-134 (1991); and K. J. Parker et al., "Tissue
response to mechanical vibrations for 'sonoelasticity imaging,'" Ultrasound Med. Biol.
30 16(3):241-6 (1990). The first MR elastographic method measured the local

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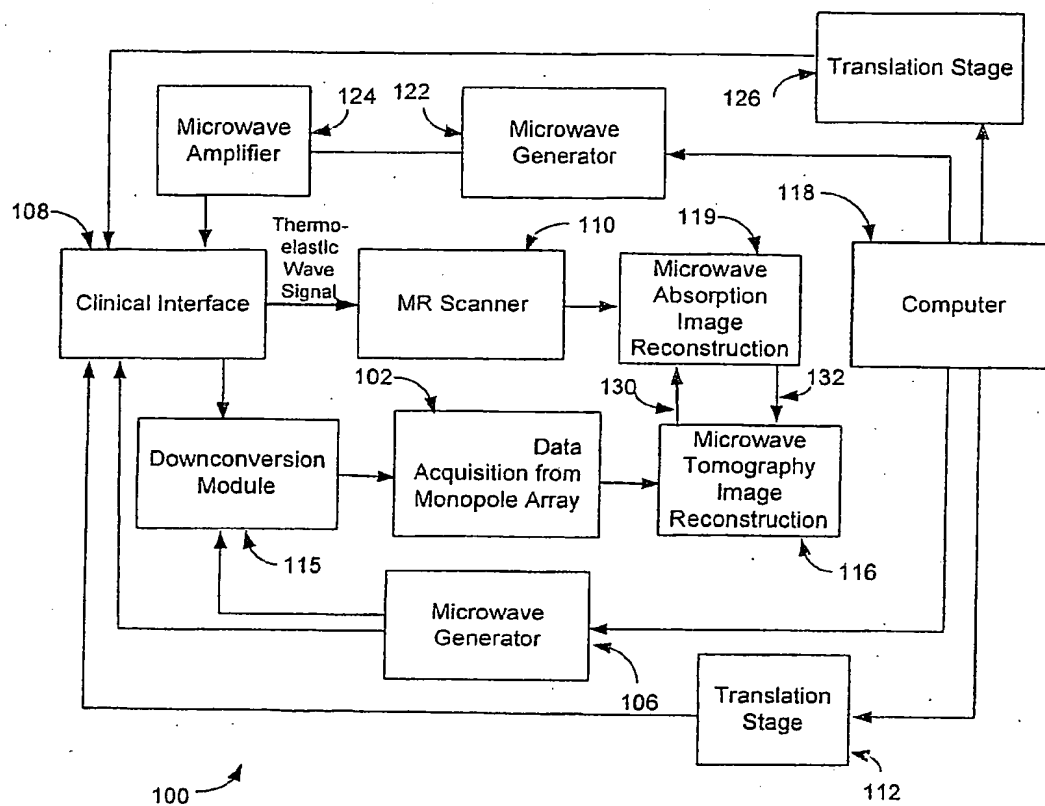


FIG. 1

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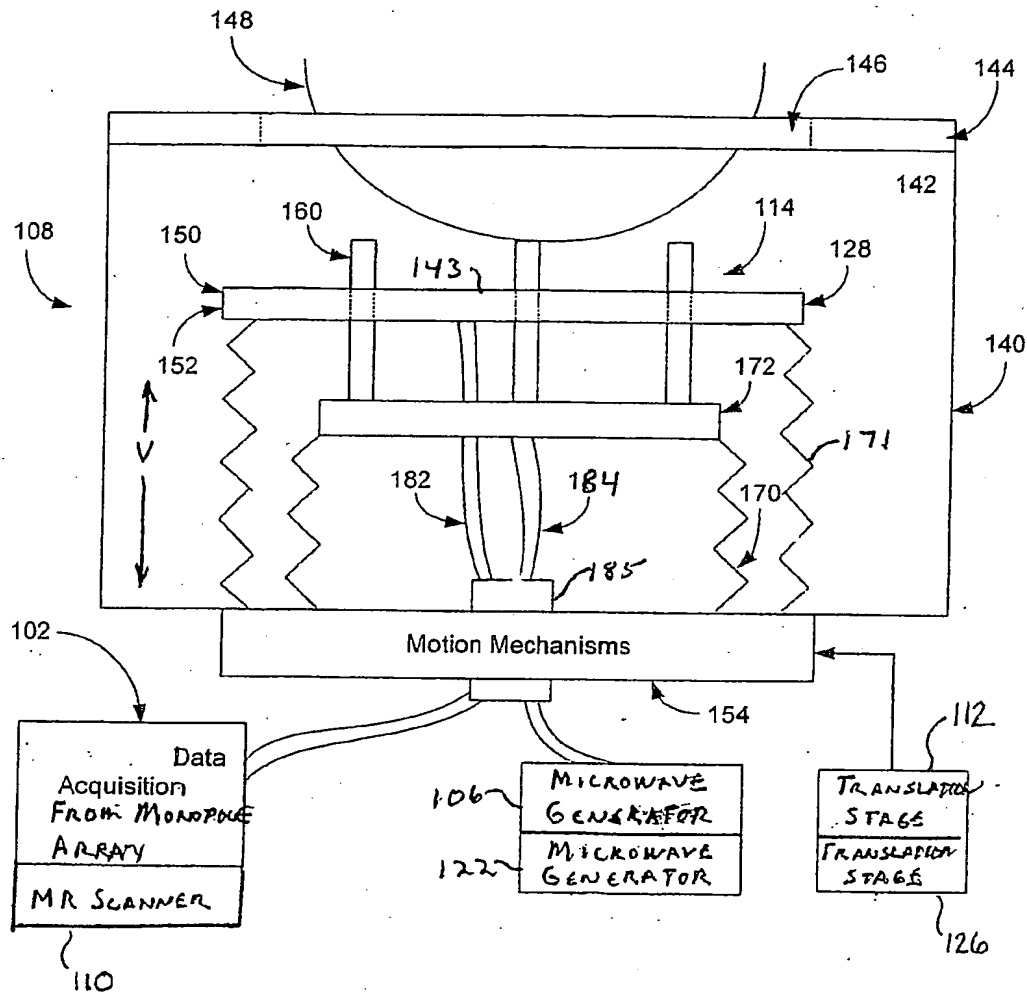


FIG. 2

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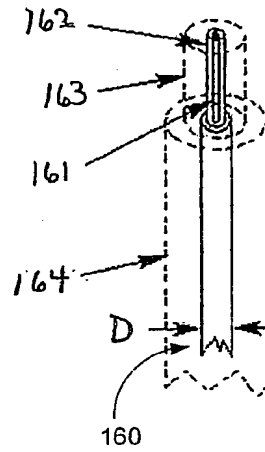


FIG. 3

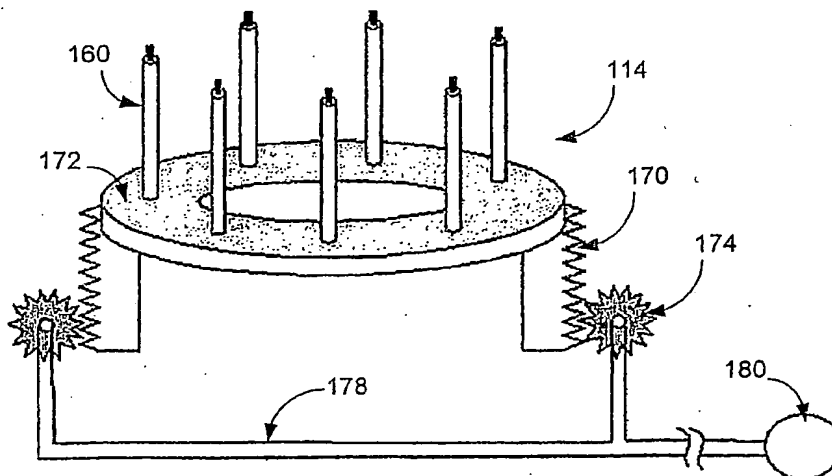


FIG. 4

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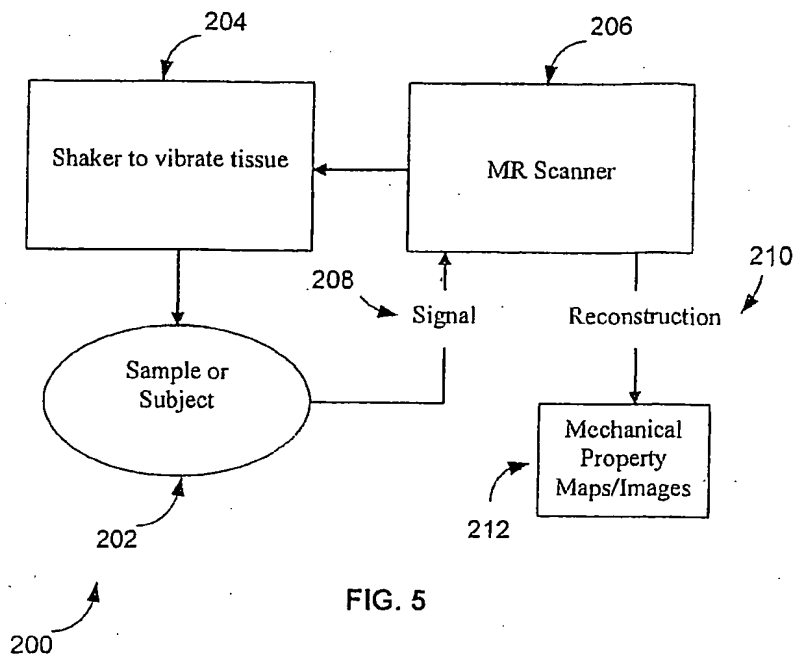


FIG. 5

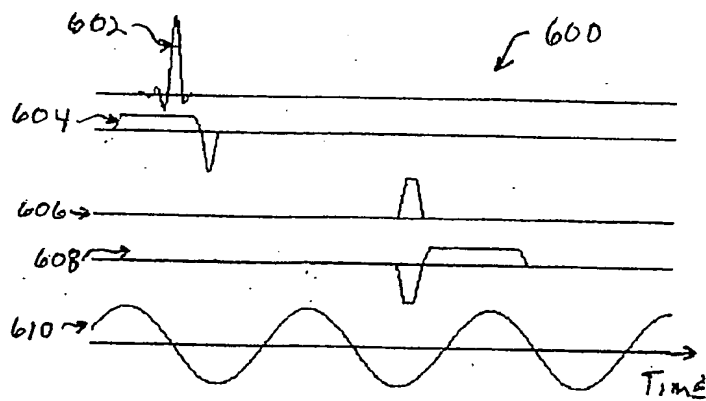


FIG. 6A

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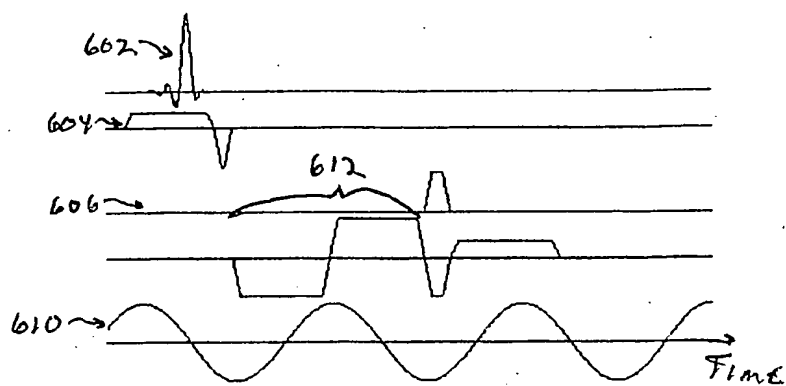


FIG. 6B

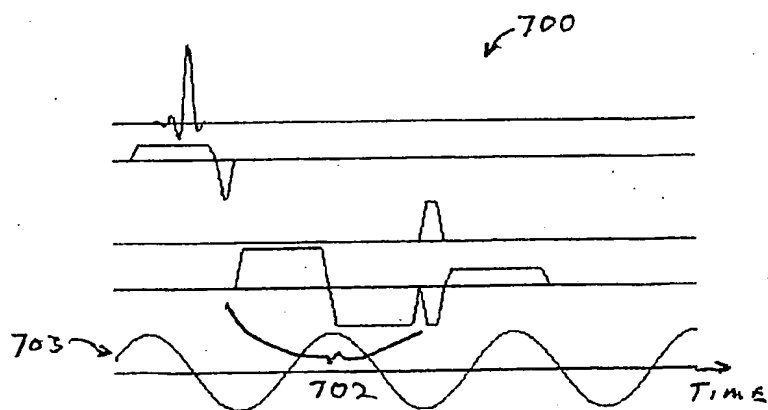


FIG. 7A

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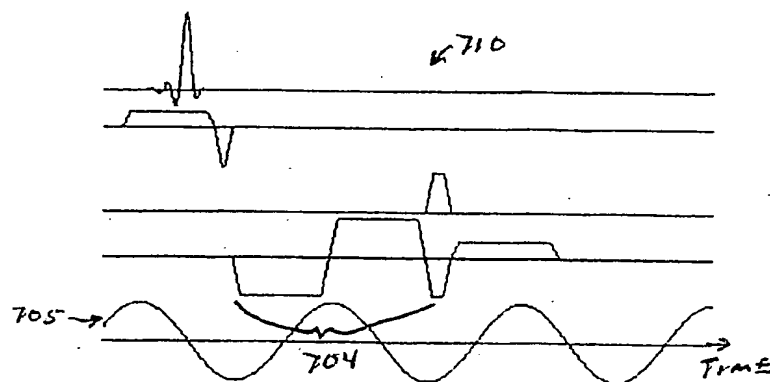


FIG. 7B

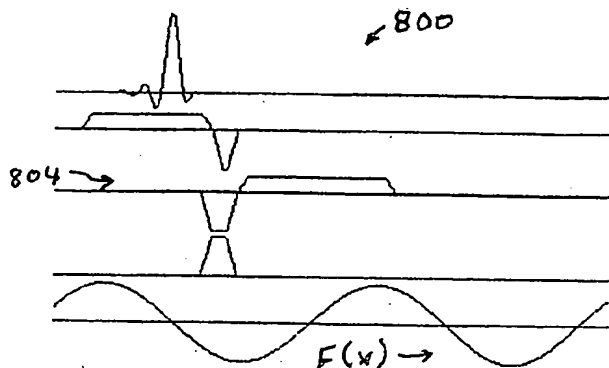


FIG. 8A

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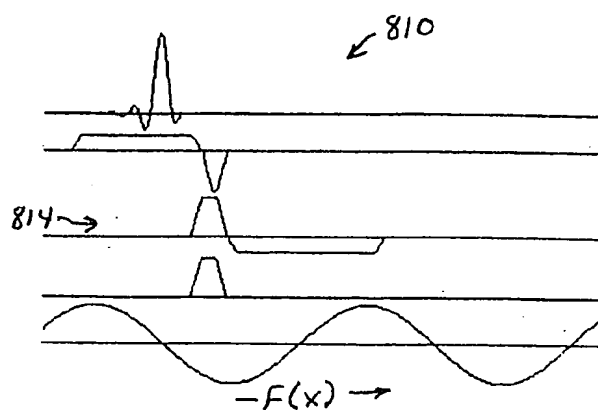


FIG. 8B

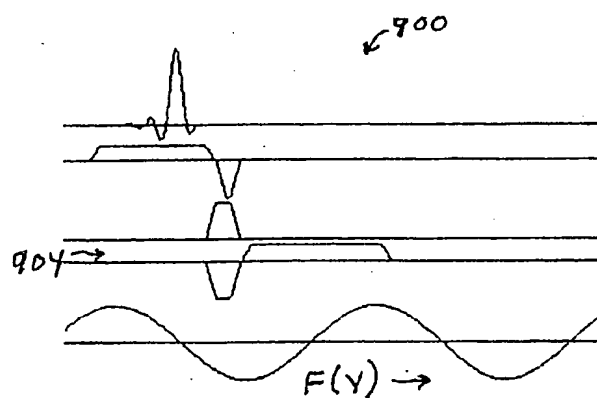


FIG. 9A

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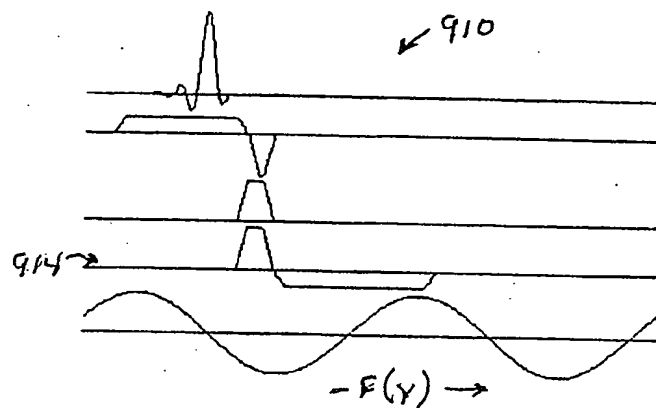


FIG. 9B

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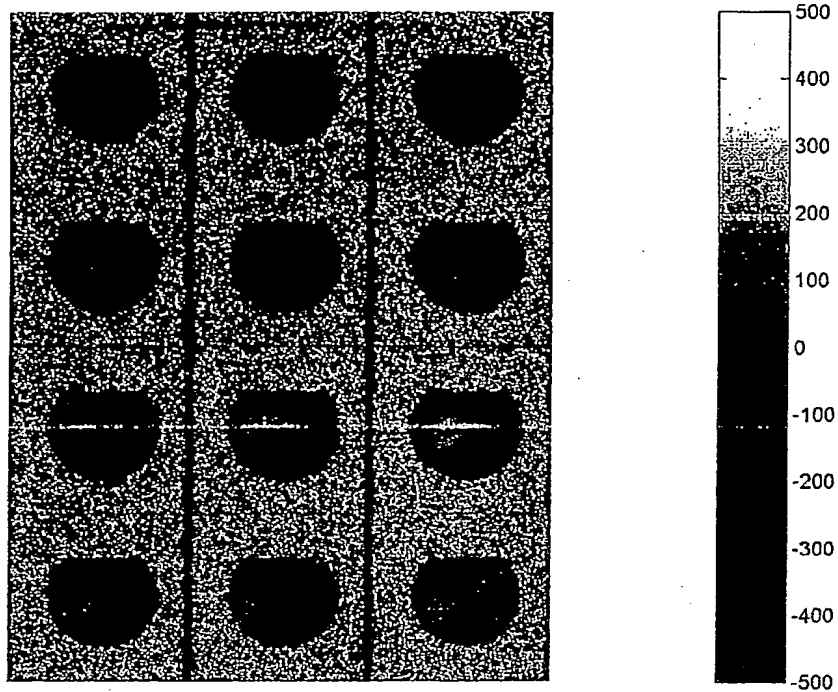


FIG. 10

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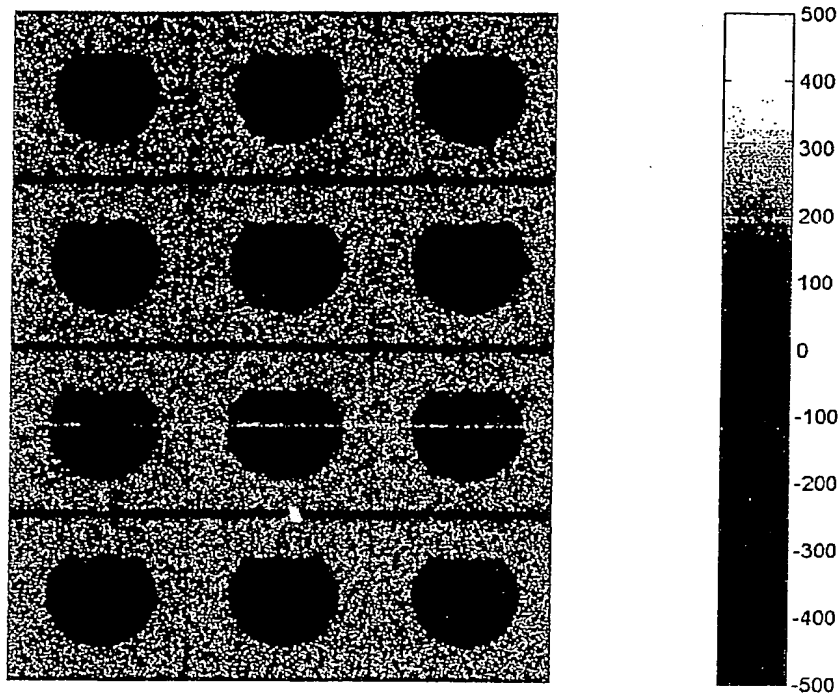


FIG. 11